PROC. ENTOMOL. SOC. WASH.
102(3), 2000, pp. 549–560

LIFE HISTORY OF THE PUTNAM SCALE, *DIASPIDIOTUS ANCYLUS* (PUTNAM) (HEMIPTERA: COCCOIDEA: DIASPIDIDAE) ON BLUEBERRIES (*VACCINIUM CORYMBOSUM,* ERICACEAE) IN NEW JERSEY, WITH A WORLD LIST OF SCALE INSECTS ON BLUEBERRIES

SRIDHAR POLAVARAPU, JOHN A. DAVIDSON, AND DOUGLASS R. MILLER

(SP) Blueberry and Cranberry Research Center, Rutgers University, Chatsworth, NJ 08019, U.S.A. (e-mail: polavarapu@aesop.rutgers.edu); (JAD) Department of Entomology, University of Maryland, College Park, MD 20742, U.S.A. (e-mail: jd12@umail.umd.edu); (DRM) Systematic Entomology Laboratory, PSI, Agricultural Research Service, USDA, Bldg. 005, BARC-W, Beltsville, MD 20705, U.S.A. (e-mail: dmiller@sel.barc.usda.gov)

Abstract.—Life history of the Putnam scale was investigated during 1997 and 1998 on highbush blueberries in the pine barrens of southern New Jersey. Putnam scale has two generations each year. Crawler emergences in the first and second generations peaked during late May and early to mid-August, respectively. This species overwinters as second instar nymphs, primarily under the bark (cork cambium) of the host. Adult females that occur on or under the bark of blueberries differ morphologically from those on the leaves and fruit. Descriptions of both forms are provided. Nine species of parasitoids were reared from canes containing Putnam scale infestations and peak emergence times of the parasitoids coincided with the transition between the adult females and crawlers.

Key Words: scale insect, life history, armored scale, Putnam scale, blueberry, pest, parasitoids, lady beetles, *Diaspidiotus ancylus*

Scale insects are frequently cited as pests of blueberries (Marucci 1966, Milholland and Meyer 1984, Antonelli et al. 1992), but there often is considerable misinformation about the species that are causing problems. Examples of erroneous statements from the literature include: terrapin scale, *Mesolecanium nigrofasciatum* (Pergande) secretes a rigid cover over its body (Milholland and Meyer 1984); Putnam scale overwinters as fully developed adults (Antonelli et al. 1992); all scale insects on blueberries have a single generation each year (Milholland and Meyer 1984); Putnam scale secretes honeydew which covers leaves and fruit and interrupts normal plant growth (Marucci 1966). In fact, terrapin scale does not secrete a cover, but the hard, banded structure that is evident on the host plant is the body of the adult female; Putnam scale is only known to overwinter as second-instar males and females (Tinker 1957, Stimmel 1976); Putnam scale is reported to have two generations each year in Delaware (Bray 1974); armored scales do not secrete honeydew but concentrate the anal secretion and incorporate it into the scale cover (Foldi 1989).

The purpose of this paper is to provide definitive information on the life history of Putnam scale on blueberries in the pine barrens of southern New Jersey, to provide detailed illustrations of the leaf and stem forms of the species, to give information on natural enemies reared during life-history studies, and to provide a list of the scale-insect species that occur on blueberries and other *Vaccinium* hosts. Phenological information on Putnam scale will enable the development of effective management strategies timed to coincide with the occurrence of susceptible stages. Data on natural enemies should assist pest management specialists in the development of IPM programs that do not affect natural-enemy populations. The list of scale-insect species on blueberries provides general information on the distribution of species and heightens awareness of the diverse scale fauna that could become pests of blueberries.

The pest status of Putnam scale is variable. Large populations are reported to reduce plant vigor (Antonelli et al. 1992). It also is an aesthetic pest; the fruit can be deformed because of depressions formed under aggregated females, and the scale covers appear as white spots on the berries. Feeding on leaves and green stems causes red areas around the feeding site. Regular pruning to remove older canes appears to keep Putnam scale populations from becoming a serious problem (Weiss and Beckwith 1945, Marucci 1966). Application of dormant oil before the plant blossoms also is an effective control method (Marucci 1966).

Putnam scale life history and identification is complicated by the presence of different morphs on different parts of the bush. Host-position dimorphism was first discovered on maple by Stannard (1965). He provided evidence that the bark form was typical of *Aspidiotus* (= *Diaspidiotus*) *ancylus*, but when bark females produced crawlers that settled on leaves the resulting leaf adults were typical of *Aspidiotus howardi* Cockerell or *A. comstocki* Johnson. Stannard (1965) stated that more than 90% of the leaf population dispersed back to the twigs in late summer as crawlers and implied that a significant proportion of the summer-generation crawlers settled on the leaves of the host. The bark form (Fig. 3) was characterized by having the second pair of pygidial lobes either absent or greatly reduced, and by having the interlobular plates with only small fimbriations. The leaf form (Fig. 4) has large second lobes and the plates have conspicuous fimbriations. These differences are so significant that the bark form was placed in the genus *Diaspidiotus* (Borchsenius 1966) and the leaf form was put in *Abgrallaspis* (Balachowsky 1953).

A summary of the literature on the life history of Putnam scale is as follows. This species has one generation each year in northern areas (e.g., Iowa, parts of New Jersey, Ohio, and Pennsylvania) and two generations in southern areas (e.g., southern Illinois and Delaware). Crawlers are reported in late spring or early summer in Iowa (Putnam 1880), in May and July in Delaware (Bray 1974), before midsummer in Ohio (Houser 1918), in May or June and midsummer in Illinois (Stannard 1965). Stimmel (1976) states that crawlers are present in Pennsylvania (a one generation per year area) for 4–5 weeks and are active through late July. In Illinois, Tinker (1957) reports crawler peaks in the third week of June and again in the second week of August. The species overwinters as second instars on the bark of twigs in both single-generation (Stimmel 1976) and two-generation areas (Tinker 1957). In Illinois, Tinker (1957) reported that females lay an average of 49 eggs at a rate of 2–3 eggs each day; eggs hatch in about 16 hours. Adults appear in May and July in Illinois (Tinker 1957) and in April in Pennsylvania (Stimmel 1976).

The known parasitoids of the Putnam scale are as follows: Aphelinidae: *Coccobius* (= *Phycus*) *varicornis* (Howard); *Encarsia* (= *Prospaltella*) *aurantii* (Howard); *E.* (= *Aspidiotiphagus*) *citrinus* (Craw) (Gordh 1979). Tinker (1957) reared six "eulophid" species from this scale in Illinois, but the identity (and family assignment) of these species is unknown.

Methods

Monitoring the life history of Putnam scale was undertaken using two methods.

Crawler emergence was monitored using sticky-tape traps (Scotch™ poster tape #109, 3M Company, St. Paul, MN) wrapped around infested canes as described by Dreistadt et al. (1994). The sticky-tape traps were placed on at least seven different plants in two different locations (near Browns Mills, Burlington County, New Jersey, and Rutgers Blueberry and Cranberry Research Center, Chatsworth, Burlington County, New Jersey). At the Browns Mills location 'Bluecrop' blueberries were sampled and at Chatsworth the field contained a mixture of mid-season varieties. Some plants contained two sticky-tape traps and each location had 10 to 12 sampling sites. The sticky-tape traps were replaced at about weekly intervals and were examined using a Nikon SMZ-U stereo microscope at 30–40× magnification. The total number of crawlers on each sticky-tape trap was counted and recorded for each sampling interval.

The second method of life-history monitoring was undertaken by examining woody canes (and the leaves and fruit at their apex) that were pruned from plants at the Rutgers Blueberry and Cranberry Research Center, Chatsworth. Two sites were sampled; one from the northern part of the blueberry breeding plot near the area sampled using sticky tapes, and one from a southern area of the same breeding plot. Five canes were taken from each location and were examined in the laboratory using a Wild Photomakroskop M400 stereomicroscope at 30–60× magnification. From each location the sex and life-history stage of the first 50 specimens encountered were recorded; observations on parasite emergence, predator activity, and scale behavior were made during the counting process. Samples were taken approximately once each month.

The following technique was used to collect the parasitoids in the samples. After completing the counting process, heavily infested pieces of blueberry cane were placed in clean 2 lb. 7 oz. coffee cans that were covered by tissue paper and held in place by plastic lids with the centers cut out. Each can contained an average of 10 twigs, five inches long, between ½ and 1 inch in diameter. All parasitoids that emerged in the cans were collected in alcohol and submitted for identification.

Search of the literature for species of scale insects on *Vaccinium* was not exhaustive, but included the majority of the species on this host genus. Primary sources of information were: ScaleNet which is part of the database system within the Systematic Entomology Laboratory's web site (http://www.sel.barc.usda.gov), Borchsenius (1966), Dekle (1976), Hamon and Williams (1984), Kozár (1998), Howell and Kosztarab (1972), Lambdin and Kosztarab (1977).

Results

Putnam scale life history.—The Putnam scale has two generations each year in the blueberry growing areas of the pine barrens of southern New Jersey (Fig. 1). Peak crawler emergences were in late May and early June for the first generation, and early to mid-August for the second (Figs. 2a, b). Second-instar males and females were the overwintering stages, and they were predominant under the bark of old canes.

Spring activity began in early February when second-instar males began to molt to third instars. By the end of March most second-instar females had transformed into adults (3rd instar) and males had matured to pupae (4th instar) and adults (5th instar) (Tables 1–2). In late April most of the population was in the adult-female stage indicating that adult males had emerged, mated, and died. Crawlers (1st instars) began to appear in mid-May and were present for the rest of the growing season into October. However, there were two distinct peaks in crawler abundance coinciding with the beginning of the two annual generations (Figs. 2a, b). In early to mid-July, the number of crawlers taken on the sticky-tape traps decreased significantly and signaled the transition between generations. In most instances, the sticky-tape traps at this time of year

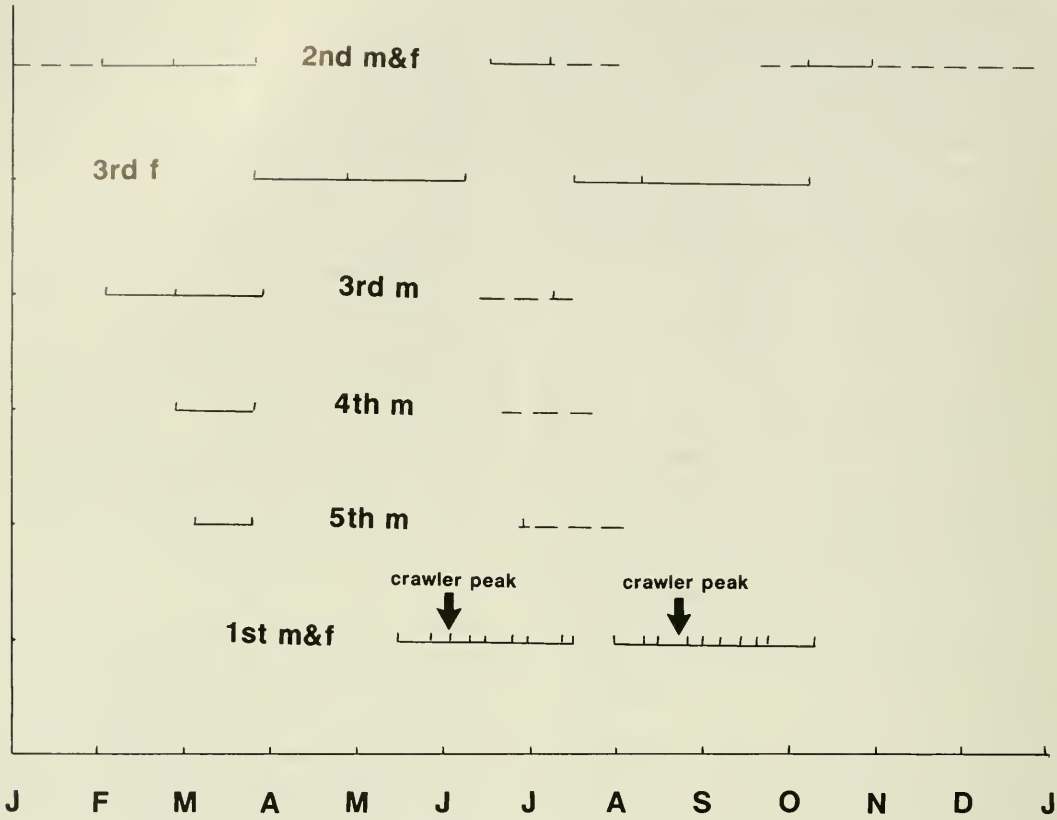

Fig. 1. Seasonal occurrence and duration of various instars of *Diaspidiotus ancylus* through the 1998 growing season at Rutgers Blueberry and Cranberry Research Center, Chatsworth, NJ. Points on the life-history bars are actual observations. Doted lines are given when direct observations of a particular instar were not made, but they are surmised to be present based on indirect evidence (m = male; f = female).

were without crawlers, but a few contained a small number (Figs. 2a, b). Crawlers seemed to prefer settling under the flaky bark on older canes, but small numbers also settled on the undersides of leaves and fruit. As the crawlers mature, the tan cork cambium of the bark grows over the scale cover, and the only evidence that a scale insect is present is a rounded swelling on the bark. Peak emergence of crawlers at Browns Mills occurred a few days after peak emergence at Chatsworth, most likely because of slightly lower temperatures at Browns Mills.

Second instars were first collected in mid June and were apparently present until mid-July (Tables 1–2). Second-instar males began to elongate their scales in late June and became distinguishable from the round scales of the second-instar females at that time. We did not find sufficient numbers of males in the second generation to make good observations on their developmental time frame. Many empty male scale covers were found in samples from July 9 suggesting that adult males had already emerged. We found a few adult males on the sticky-tape traps from June 26. Adult females were first detected in mid-June, but scale covers were not enlarged until mid-July. Observations from the August 11 sample indicate that about half of the adult females had eggs under their scale covers. The remaining females had not yet begun to lay eggs. Crawlers of the second generation began to appear in late July; peak

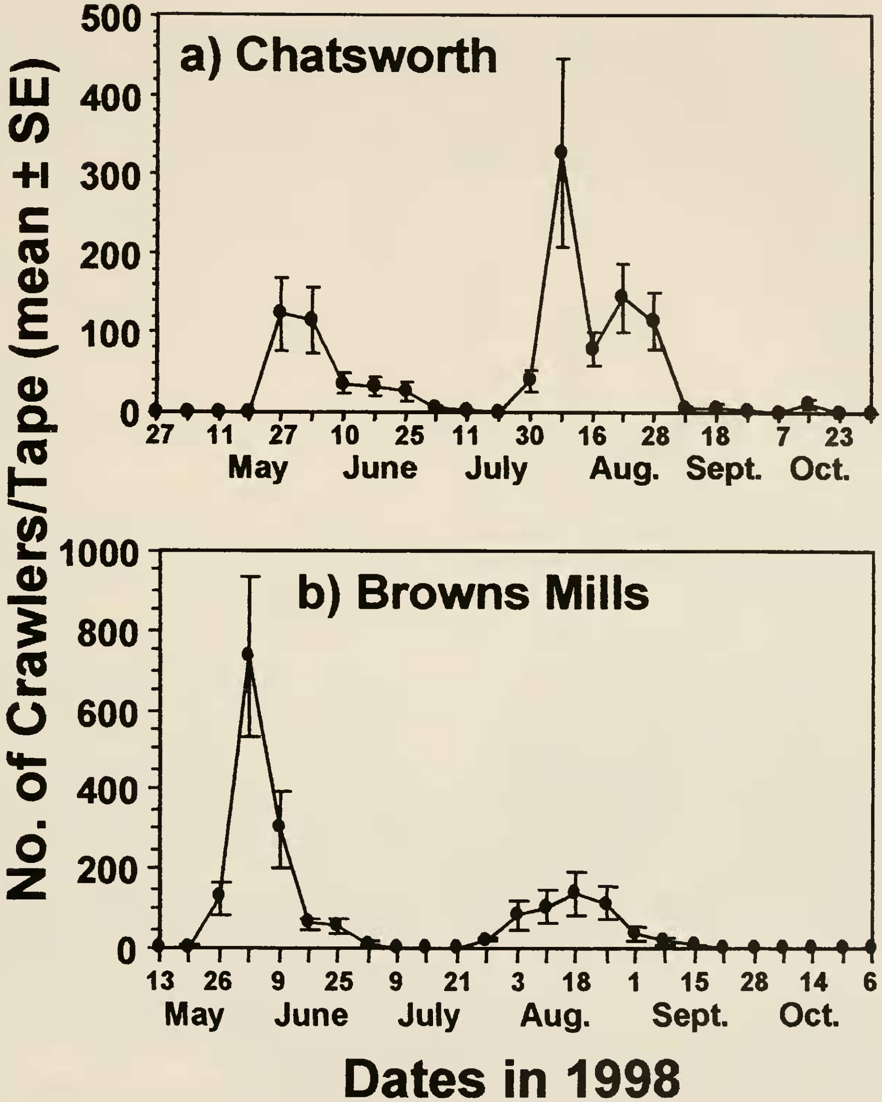

Fig. 2. Crawler abundance (mean number per sticky-tape trap ± SE) of *Diaspidiotus ancylus* at Rutgers Blueberry and Cranberry Research Center, Chatsworth, NJ, (a) and at Browns Mills, NJ (b) during 1998 growing season.

numbers were found on the sticky-tape traps in early August at the Blueberry and Cranberry Research Center and slightly later at the Browns Mills location (Figs. 2a, b). Second instars first appeared in early September and by late October were the only stage present. In the October 30 sample, second-instar males had begun to elongate their scale covers and were distinguishable from second-instar females at that time.

Host-position dimorphism.—Studies were undertaken to examine morphological differences induced by settling site locations. Specimens collected on the stems and even leaf petioles showed the morphology typical of the ancylus form (Fig. 3) that have the second lobes absent or reduced to

Table 1. Percent of *Diaspidiotus ancylus* populations in each instar during the 1998 growing season at the north side of the blueberry breeding plot at the Rutgers Blueberry and Cranberry Research Center, Chatsworth, NJ. A total of 50 specimens were examined on each sampling date. Abbreviations are m = male; f = female.

	Percent of Population in each Instar Dates in 1998								
Instars	2/2	2/26	3/26	4/30	6/18	7/9	8/11	10/9	10/30
Settled 1st					30		36	4	
Active 1st					8		22		
2nd m or f?					56				100
2nd f	54	60	6					92	
2nd m	12	2				2			
3rd f			56	100	6	96	42	4	
3rd m	34	8	6			2			
4th m		30	16						
5th m			16						

small points (Fig. 3A), the plates between the median and second lobes have small fimbriations (Fig. 3B) (compared to the howardi-comstocki form), with 18–48(31) macroducts on each side of the pygidium (Fig. 3C), 9–22(15) perivulvar pores on each side of the pygidium (Fig. 3D), and many microducts near the dorsomarginal area of the thorax and head (Fig. 3E). Specimens collected on fruit and leaves showed the morphology typical of the howardi or comstocki forms (Fig. 4) that have well-developed second lobes (Fig. 4A), the plates between the median and second lobes have large fimbriations (Fig. 4B), (compared to the ancylus form), with 12–22(17) macroducts on each side of the pygidium (Fig. 4C), 8–10(9) perivulvar pores on each side of the pygidium (Fig. 4D), and few or no microducts near the dorsomarginal area of the thorax and head (Fig. 4E). In some cases intermediate forms are collected particularly on green stems and leaf petioles.

Table 2. Percent of *Diaspidiotus ancylus* populations in each instar during the 1998 growing season at the south side of the blueberry breeding plot at the Rutgers Blueberry and Cranberry Research Center, Chatsworth, NJ. A total of 50 specimens were examined on each sampling date. Abbreviations are m = male; f = female.

	Percent of Population in each Instar Dates in 1998						
Instars	3/26	4/30	6/18	7/10	8/11	10/9	10/30
Settled 1st			22		34	22	
Active 1st			22		34		
2nd m or f?			54			78	100
2nd f	60						
2nd m							
3rd f		100	2	100	32		
3rd m	4						
4th m	36						
5th m							

There also is a striking difference in the appearance of the scale cover between the leaf-fruit form and the bark form. The howardi-comstocki form on the fruit has a conspicuously white scale cover with a slight grayish tinge and is never under the outer cell layer of the host. The ancylus form on the bark has the scale cover dark gray and is usually hidden under the host cork cambium.

Information on natural enemies.—Based on parasitoid rearing data, there were two occurrence peaks of adult parasitoids. The sample from April 30 had an emergence of more than 50 adult parasitoids. This time frame coincided with the predominance of adult females just before the first crawlers appeared. The sample from August 11 had an emergence of about 100 adult parasitoids. The scale population at this time was near the end of the first generation, with adult females predominantly laying eggs and with crawlers of the second generation the most abundant life stage. The parasitoids that were collected are as follows:

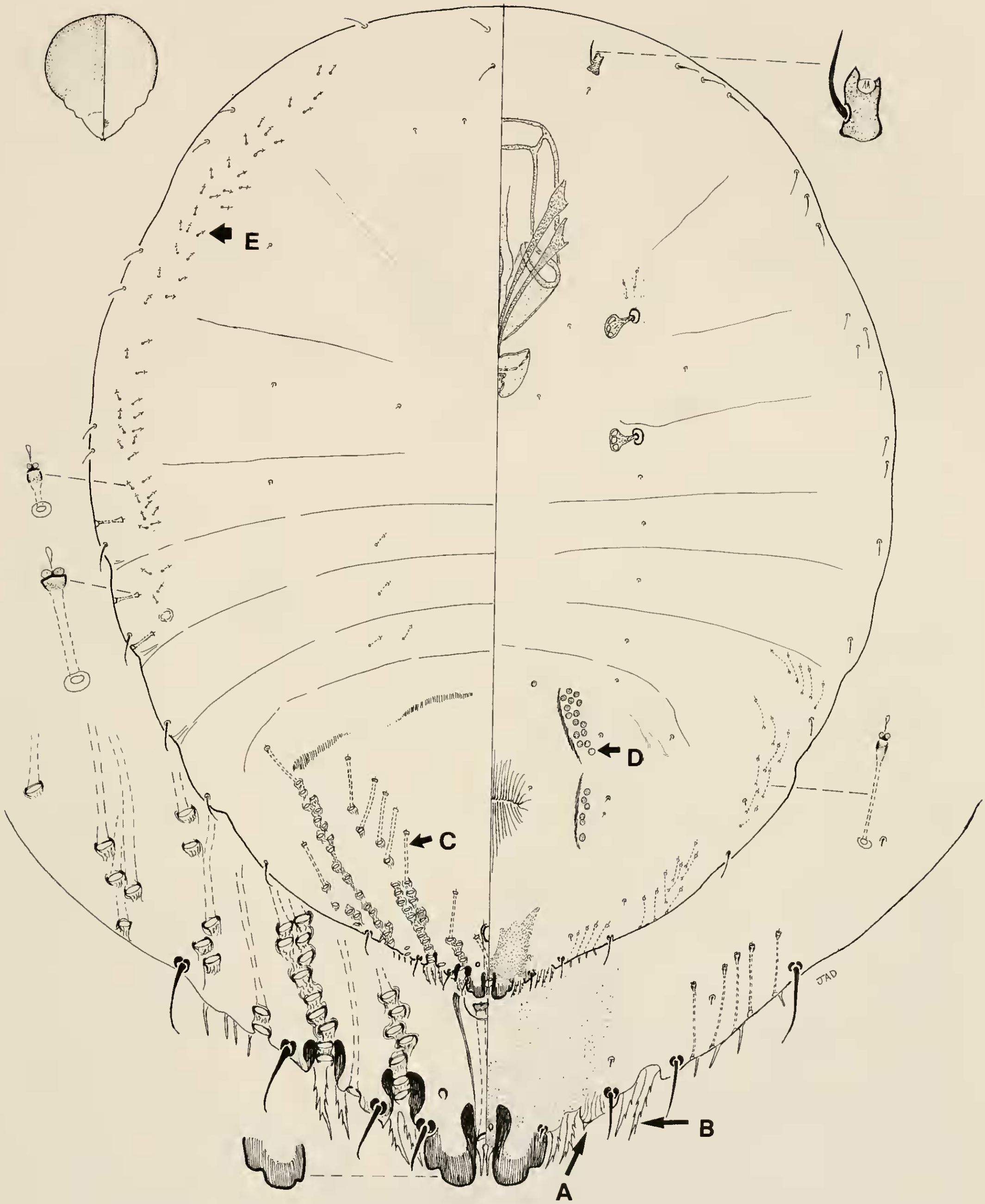

Fig. 3. Bark form (ancylus form), adult female *Diaspidiotus ancylus*. A, Second lobe; B, Interlobular plates; C, Macroducts; D, Perivulvar pores; E, Microducts.

Aphelinidae: *Ablerus clisiocampae* (Ashmead); *Coccobius varicornis* (Howard); *Coccophagoides* sp. #1; *Coccophagoides* sp. # 2; *Encarsia* sp.; *Encarsia aurantii* (Howard); *Marietta carnesi* (Howard). Encyrtidae: *Epitetracnemus intersectus* (Fonscolombe). Signiphoridae: *Signiphora* sp. The most abundant parasitoids were *Able-*

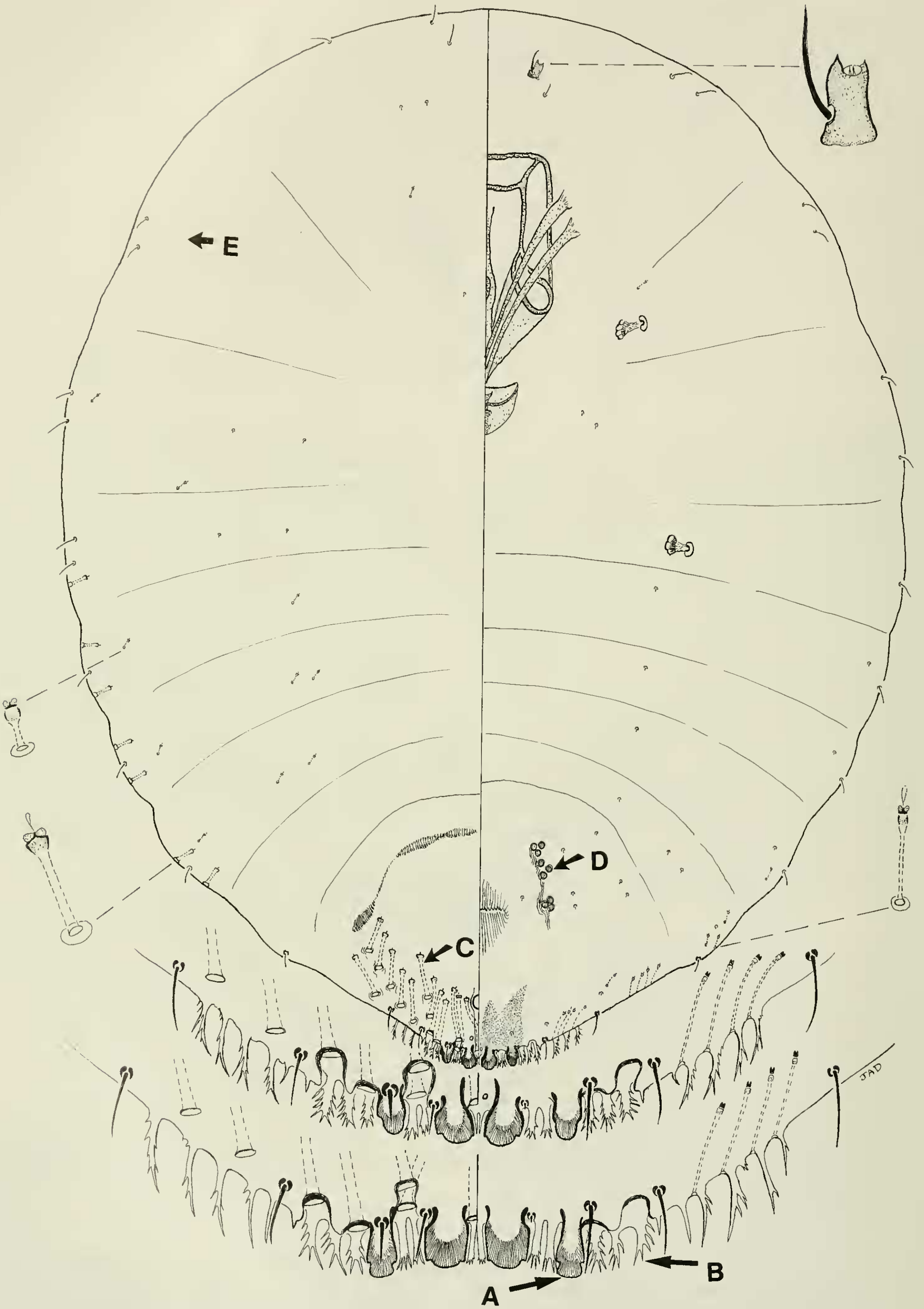

Fig. 4. Leaf and fruit form (howardi-comstocki form), adult female *Diaspidiotus ancylus* (Putnam). A, Second lobe; B, Interlobular plates; C, Macroducts; D, Perivulvar pores; E, Microducts.

rus clisiocampe and *Marietta carnesi* (Howard).; *Coccophagoides* sp. #1; *Coccophagoides* sp. # 2; and *Coccobius varicornis* were next most numerous, and the remainder were uncommon.

The lady beetle (Coccinellidae) *Microwesia misella* (LeConte) was commonly encountered during the warm parts of the year, as was an occasional *Chilocorus* specimen. Adults were found in the samples collected February 2 and April 30, and larvae were seen in the March 26 and August 11 samples. The predatory mite (Hemisarcoptidae), *Hemisarcoptes malus* (Shimer) was noticeably abundant in the August 11 sample.

Survey results.—We found the following scale species in 1997 and 1998 in commercial blueberry fields in New Jersey: Coccidae: European fruit lecanium—*Parthenolecanium corni* (Bouché) (4 locations); Cottony hydrangea scale—*Pulvinaria hydrangeae* Steinweden (2 locations); Cottony maple scale—*Pulvinaria innumerabilis* (Rathvon) (3 locations). Diaspididae: Putnam scale—*Diaspidiotus ancylus* (6 locations). Pseudococcidae: Blueberry mealybug—*Dysmicoccus vaccini* Miller and Polavarapu (7 locations).

We collected additional species in native blueberries near commercial fields in NJ as follows: Coccidae: Cottony azalea scale—*Pulvinaria ericicola* McConnell (8 locations). Pseudococcidae: Myrmecophile mealybug—*Peliococcus flaveolus* (Cockerell) (7 locations).

Other species known to occur on *Vaccinium* in the Northeastern US are: Cerococcidae: *Cerococcus kalmiae* Ferris (Eastern US, Kansas, Texas). Coccidae: Thorn scale—*Eulecanium tiliae* (Linnaeus) (US and Europe); Terrapin scale—*Mesolecanium nigrofasciatum* (Pergande) (eastern US); Cottony camellia scale—*Pulvinaria floccifera* (Westwood) (Cosmopolitan). Diaspididae: Cranberry scale—*Abgrallaspis oxycoccus* (Woglum) (Eastern US); Oystershell scale—*Lepidosaphes ulmi* (Linnaeus) (Cosmopolitan); San Jose scale—*Quadraspidiotus perniciosus* (Comstock) (Cosmopolitan); Dearness scale—*Rhizaspidiotus dearnessi* (Cockerell) (US and Mexico). Eriococcidae: Azalea bark scale—*Eriococcus azaleae* (Comstock) (US); Oak felt scale—*Eriococcus quercus* (Comstock) (US). Lecanodiaspididae: Common false pit scale—*Lecanodiaspis prosopidis* (Maskell) (US and Mexico). Pseudococcidae: *Heliococcus osborni* (Sanders) (Eastern US and Colorado); False puto mealybug—*Phenacoccus rubivorus* Cockerell (Eastern US and New Mexico); Kellogg mealybug—*Radicoccus kelloggi* (Ehrhorn and Cockerell) (US).

Other species known to occur on *Vaccinium* in parts of the US other than the Northeast are: Coccidae: Barnacle scale—*Ceroplastes cirripediformis* Comstock (Cosmopolitan); Indian wax scale—*Ceroplastes ceriferus* (Fabricius) (Cosmopolitan); Florida wax scale—*Ceroplastes floridensis* Comstock (Cosmopolitan); Chinese wax scale—*Ceroplastes sinensis* Del Guercio (Cosmopolitan); Brown soft scale—*Coccus hesperidum* Linnaeus (Cosmopolitan); Pyriform scale—*Protopulvinaria pyriformis* (Cockerell) (Tropical areas); Cottony maple leaf scale—*Pulvinaria acericola* (Walsh and Riley) (Eastern US); (Southern US, Pacific Islands, Caribbean Islands, Galapagos Islands, Israel) Urbicola soft scale—*Pulvinaria urbicola* Cockerell (Southern US, Pacific Islands, Caribbean Islands, Galapagos Islands, Israel); Hemispherical scale—*Saissetia oleae* (Olivier) (Cosmopolitan). Diaspididae: Cyanophyllum scale—*Abgrallaspis cyanophylli* (Signoret) (Cosmopolitan); Red bay scale—*Acutaspis perseae* (Comstock) (New World and Europe); Oleander scale—*Aspidiotus nerii* (Bouché) (Cosmopolitan); Spinose scale—*Aspidiotus spinosus* Comstock (Cosmopolitan); Camellia mining scale—*Duplaspidiotus clavigera* (Cockerell) (Florida, Tropical areas); Tesserate scale—*Duplaspidiotus tesseratus* (Grandpré and Charmoy) (Tropical areas); Latania scale—*Hemiberlesia lataniae* (Signoret); Mimosa scale—*Melanaspis mimo-*

sae (Comstock) (Mexico, Arizona, California, and Florida); Harper scale—*Neopinnaspis harperi* McKenzie (California, Florida, Georgia, Hawaii, Japan, Taiwan); Camphor scale—*Pseudaonidia duplex* (Cockerell); White peach scale—*Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Cosmopolitan); False parlatoria scale—*Pseudoparlatoria parlatoriodes* (Comstock) (Tropical areas); Dentate scale—*Velataspis dentata* (Hoke) (Southeastern US, Panama). Eriococcidae: Texas eriococcin—*Eriococcus texanus* (King) (Western US). Pseudococcidae: Bilberry mealybug—*Cucullococcus vaccinii* Ferris (California). Putoidae: Pacific mealybug—*Puto pacificus* McKenzie (California).

Scale species known to occur on *Vaccinium* outside of the US: Coccidae: *Eulecanium distinguendum* (Douglas) (England); *Eulecanium franconicum* (Lindinger) (Europe and Former Soviet Union); *Parthenolecanium rufulum* (Cockerell) (Europe and Former Soviet Union); *Phyllostroma myrtilli* (Kaltenbach) (Europe and Former Soviet Union); *Pulvinaria peregrina* (Borchsenius) (Azerbaijan and Georgia). Conchaspididae: *Conchaspis vaccinii* Khoo (Malaysia). Diaspididae: *Aulacaspis ericacearum* Takagi (Japan); *Chionaspis salicis* (Linnaeus) (Europe, Asia, N. Africa); *Niveaspis vulcania* Ferris (Panama); *Pseudaulacaspis ericacea* (Ferris) (China); *Quadraspidiotus bavaricus* (Lindinger) (Europe); *Quadraspidiotus ostreaeformis* (Curtis) (temperate areas); *Quadraspidiotus zonatus* (Frauenfeld) (Europe, Middle East, and Africa). Eriococcidae: *Eriococcus baldonensis* (Rasina) (Finland, Latvia, Ukraine, and Russia); *Eriococcus costaricensis* (Cockerell and Robinson) (Costa Rica); *Eriococcus devoniensis* (Green) (Europe); *Eriococcus uvaeursi* (Linnaeus) (Europe). Ortheziidae: *Arctorthezia cataphracta* (Olafsen) (Europe); *Newsteadia floccosa* De Geer (Europe). Pseudococcidae: *Atrococcus bejbienkoi* Kozár and Danzig (Hungary and Former Soviet Union); *Atrococcus cracens* Williams (Europe); *Indococcus acanthodes* (Wang) (China); *Phenacoccus insularis* Danzig (Russia); *Phenacoccus vaccinii* (Danzig) (Russia); *Spinococcus calluneti* (Lindinger) (Europe). Putoidae: *Puto janetscheki* Balachowsky (France and Czechoslovakia); *Puto tubulifer* Danzig (Mongolia and Russia); *Puto vaccinii* (Coquillett) (Russia).

Discussion

It is now clear that references to the Putnam scale having only a single generation in the commercial blueberries areas near the pine barrens of New Jersey are incorrect. It also is incorrect that the overwintering stage is the adult female. Quite clearly, there are two generations each year, and the overwintering stage is the second-instar male and female.

Although we did not make a detailed comparison of the relative abundance of Putnam scale on the bark versus the leaves and fruit, it is obvious that only a very small proportion of the population is found on plant parts other than the roughened bark. The reasons for this are not clear, but there are at least two possibilities. 1) It is feasible that the preferred feeding site is under the bark, and only when this habitat is crowded will crawlers settle on sites that are less than optimal. 2) It also is possible that a large proportion of the population actually settles on exposed parts of the host but is killed by pesticides used to control other blueberry pests. Our current thinking favors hypothesis 1 since we see no evidence of massive pesticide kills of crawlers on exposed parts of the plants, and it appears that crawlers settle on host areas other than the bark only in situations where the bark is already encrusted with heavy populations of the scale. Hypothesis 1 supports the long-held belief that removal of old woody canes will prevent the Putnam scale from becoming a serious pest. Without the roughened bark of older canes to settle under, their preferred habitat is lacking, and the scales that settle on the smooth areas of the host may be more susceptible to natural enemies. Our observations suggest that there is a much higher rate of parasitism on individuals that are exposed on the fruit, leaves, or smooth bark than on those hidden under rough bark. It is interesting that every blueberry farm that we examined for Putnam scale had populations of the scale under the bark of the older canes. This suggests that these residual populations could build to pest levels if conditions encouraging their build up were to occur.

Adult parasitoids seem to be most abundant when adult females and crawlers are most prevalent. This situation is problematic because pesticide applications (other than horticultural oil sprays) are most effective against the scales during these same periods, i.e., when the crawlers are wandering on the host searching for settling sites and have yet to form a scale cover. If chemical applications are required at these times, it would probably be best to use horticultural oils at summer rates without combinations of pesticides, since residues from the latter can kill parasitoids for one or more weeks after application.

A broad diversity of scale insects has been reported to feed on *Vaccinium* hosts including highbush blueberries. At present we know of 54 species of scale insects that feed on species of *Vaccinium*. In the Northeastern U.S. there are 21 different species. In other parts of the U.S. there are seven additional species. In areas outside of the U. S. there are 26 more species. Of these 26 species, 11 have limited host ranges: *Aulacaspis ericacearum*–Ericaceae only; *Eriococcus baldonensis*–Ericaceae and one other family; *E. costaricensis–Vaccinium* only; *Eulecanium distinguendum–Vaccinium* only; *E. franconicum*–Ericaceae only; *Indococcus acanthodes–Vaccinium* only; *Niveaspis vulcania–Vaccinium* only; *Phenacoccus vaccinii*–Ericaceae only; *Phyllostroma myrtilli*–Ericaceae only; *Puto tubulifer–Vaccinium* only; *Puto vaccinii–Vaccinium* only. If any of these species were accidentally introduced into the blueberry growing areas of the U.S. there could be serious consequences.

Acknowledgments

Thanks to Vera Kyryczenko, Blueberry and Cranberry Research Center, Rutgers University (BCRC) for assistance in examining sticky-tape traps. We are grateful to Michael E. Schauff and Robert D. Gordon, Systematic Entomology Laboratory, Agricultural Research Service, United States Department of Agriculture, Washington, D.C. (SEL) for respectively identifying the Chalcidoidea and Coccinellidae reported in this manuscript. To John Bertino, Walt Adams, and Paul Macrie we extend special appreciation for allowing us to study scale populations on their properties. We also are grateful to Devon Fowler for assistance in collecting samples from Variety Farms, Hammonton, New Jersey. This research was partially funded by a grant from the New Jersey Blueberry-Cranberry Research Council and CSREES grant (97-34155-3959) awarded to SP.

We are grateful to the following individuals for reading and commenting on the manuscript: James F. Stimmel, Pennsylvania Department of Agriculture, Bureau of Plant Industry, Harrisburg; Michael E. Schauff and F. Christian Thompson, SEL.

Literature Cited

Antonelli, A., E. Elsner, and C. Shanks. 1992. Arthropod management. pp. 55–75. *In* Pritts, M. P., J. F. Hancock, and B. Strik, eds., Highbush Blueberry Production Guide. Northeast Regional Agricultural Engineering Service Bulletin 55, 199 pp.

Balachowsky, A. S. 1953. Sur un *Hemiberlesia* Ckll. nouveau des montagnes du Caméroun. (Homoptera; Coccoidea). [Contribution à l'étude des Coccoidea de la France d'Outre mer, 8e note.] Beitrage zur Entomologie. 3: 111–115.

Borchsenius, N. S. 1966. A Catalogue of the Armoured Scale Insects (Diaspidoidea) of the World. (In Russian). Nauka, Moscow & Leningrad. 449 pp.

Bray, D. F. 1974. The Fieldman's Guide to Entomology. Special Bulletin, Cooperative Extension Service, University of Delaware. 33 pp.

Dekle, G. W. 1976. Florida armored scale insects. *In* Arthropods of Florida and neighboring land areas. Florida Department of Agriculture and Consumer

Services, Division of Plant Industry, Vol. 3: 1–345.

Dreistadt, S. H., J. K. Clark, and M. L. Flint. 1994. Pests of Landscape Trees and Shrubs. University of California, Division of Agriculture and Natural Resources, Publication 3359, 327 pp.

Foldi, I. 1989. 1.1.2.4 The scale cover, pp. 43–54. *In* Rosen, D., ed., Armoured Scale Insects, Their Biology, Natural Enemies and Control, Vol. A. Elsevier, Amsterdam, the Netherlands, 384 pp.

Gordh, G. 1979. Encyrtidae, pp. 890–967. *In* Krombein, K. V., P. D. Hurd, D. R. Smith, and B. D. Burks, eds., Catalog of the Hymenoptera of America North of Mexico, Vol. 1. Smithsonian Institution Press, Washington, D.C., 1,198 pp.

Hamon, A. B. and M. L. Williams. 1984. The soft scale insects of Florida (Homoptera: Coccoidea: Coccidae). *In* Arthropods of Florida and Neighboring Land Areas. Florida Department of Agriculture & Consumer Services, Division of Plant Industry, Gainesville, 194 pp.

Houser, J. S. 1918. Destructive insects affecting Ohio shade and forest trees. Bulletin of the Ohio Agricultural Experiment Station 332: 165–487.

Howell, J. O. and M. Kosztarab. 1972. Morphology and systematics of the adult females of the genus *Lecanodiaspis* (Homoptera: Coccoidea: Lecanodiaspididae). Research Division Bulletin Virginia Polytechnic Institute and State University, Blacksburg 70: 1–248.

Kozár, F., ed. 1998. Catalogue of Palaearctic Coccoidea. Plant Protection Institute, Hungarian Academy of Sciences, Budapest, Hungary. 526 pp.

Lambdin, P. L. and M. Kosztarab. 1977. Morphology and systematics of the adult females of the genus *Cerococcus* (Homoptera: Coccoidea: Cerococcidae). Research Division Bulletin Virginia Polytechnic Institute and State University, Blacksburg 128: 1–252.

Marucci, P. E. 1966. Insects and their control, pp. 199–236. *In* Eck, P. and N. F. Childers, eds., Blueberry Culture. Rutgers University Press, New Brunswick, New Jersey, 378 pp.

Milholland, R. D. and J. R. Meyer. 1984. Diseases and arthropod pests of blueberries. The North Carolina Agricultural Research Service, Raleigh, 33 pp.

Putnam, J. D. 1880. Biological and other notes on Coccidae. Proceedings of the Davenport Academy of Natural Sciences (1879–1880) 2: 293–347.

Stannard, L. J. 1965. Polymorphism in the Putnam's scale, *Aspidiotus ancylus* (Homoptera: Coccoidea). Annals of the Entomological Society of America 58: 573–576.

Stimmel, J. F. 1976. Putnam scale, *Diaspidiotus ancylus* (Putnam), Homoptera: Diaspididae. Regulatory Horticulture 2(1): 19–20.

Tinker, M. E. 1957. Effect of DDT on the bionomics of Putnam scale. *Aspidiotus ancylus* Putn.) (Hemiptera, Coccidae), Ph.D. Dissertation, Entomology Graduate College of the University of Illinois.

Weiss, H. B. and C. S. Beckwith. 1945. The cultivated blueberry industry in New Jersey, including a report on the insects of the cultivated blueberry. New Jersey State Department of Agriculture, Circular 356, 23 pp.